Contents

Boxes

Figures

Tables

Chapter 3
Planning for an Uncertain Future

Natural resource planners have always prepared plans without complete knowledge of how the future will unfold. By recognizing a wide range of future uncertainties, planners can prepare plans that are more robust and successful, even if conditions unfold differently than anticipated.

This chapter identifies some future uncertainties for planners to consider when preparing resource management plans. It also presents a new analytical approach to be refined over the next several years and to be used in preparation of California Water Plan Update 2008. The major change in this analytical approach from past water plan updates is the evaluation of multiple plausible future scenarios rather than a single projected future. The California Department of Water Resources (DWR) expects to evaluate several different response packages, or sets of resource management strategies (see Volume 2), for each future scenario for update 2008. This refined analytical approach combined with the integrated resource planning principles in Chapter 4 should result in more durable statewide and regional plans.

Overview of Uncertainty and Scenarios

Each region of the state faces its own set of uncertainties in planning to meet future resource needs. Population may grow faster or slower than past trends. Evolving scientific understanding can lead to changes in instream flow to meet fish needs. New information on human health effects from certain constituents found in water can require changes in water treatment. These and many other uncertainties can unfold in a variety of ways and alter the future viability of plans that are prepared today.

We cannot wait to resolve all uncertainties before preparing plans for the future. Rather, the State and regional entities need to evaluate potential effects of uncertainties as part of resource planning. An effective plan includes a diversified portfolio of resource management strategies; that is, projects, programs, or policies that help entities manage their water and related resources (see Volume 2). Strategies can be combined in various ways to meet water management objectives and values of different regions and to achieve benefits for many natural resources. Some strategies are more resilient and remain useful regardless of a region's future conditions. Some built-in redundancy in a water management system can provide operational flexibility or serve as insurance in case an extreme event disables a portion of the system. A clear understanding of future uncertainties allows resource managers to better assess risks associated with different management plans. Some regions are willing to accept more risk in their plans than are neighboring regions who choose a different mix of resource management strategies.

Future scenarios, as used in this water plan update, describe different conditions over which resource managers have little or no control. Where people decide to live, what mix of industrial activity develops in a region, crops that farmers decide to grow, and new regulations for instream flow are future changes that can happen regardless of resource planning today. Future scenarios do not represent what different interest groups hope for the future. Those visions are part of the method used to evaluate response packages (see response package discussion later in this chapter).

In preparing this water plan update, DWR and stakeholders considered numerous factors that could vary in the future. Because it would not be practical to try to evaluate variations in hundreds of different factors, variations of potential differences in land use and related water use provided a logical place to begin the analysis.

The following sections show some of the uncertainties in future conditions for planners to consider. By considering different future scenarios, each with different management responses, planners will be able to test the performance of responses under many of the uncertainties. For example, one response package may be more water use intensive and another may be less water use intensive. The Approach for Future Analysis section later in this chapter includes more description of potential future scenarios and response packages.

Future Landscape (Land Use Patterns)

The way in which we use land—the types of use and the level of intensity—has a direct relationship to water supply and water quality. It is impossible to predict precisely how land will be used in the future. People may decide to relocate to certain regions. Farmers may change cropping patterns in response to world markets. By better understanding the uncertainties over future land use patterns, we can better plan for those changes.

Projecting current trends has traditionally been the method for estimating future water demand. However, there are many economic, environmental, and social factors that cause future conditions to vary from existing trends. Changes in job conditions can force people to move from one region to another or from state to state. Changes in the world food market can influence California farmers to alter crop types and crop acreage. Changes in scientific understanding of the environment can encourage habitat restoration or alter instream flows. Many factors like these can lead to land and water use patterns different from what were expected by simply projecting current trends.

Unknown forces influence future urban, agriculture, and environmental land use patterns. A good way to prepare for these future uncertainties is to build a diversified portfolio of resource management strategies. Often, the unknown is timing. For example, an estimated population for the year 2030 may actually be reached in 2025 or 2035. In this case, the mix of strategies in the plan will likely remain the same, but their timing may be different. The plan can simply be implemented incrementally at a faster pace or portions can be delayed for a few years. The following sections provide some considerations in planning for uncertainties in land use patterns.

Urban

According to the Department of Finance, California's year 2003 population of more than 36 million is expected to swell by an additional 12 million people to 48 million by year 2030. However, actual population growth will certainly be more or less than this estimate. More people means more changes in land use, leading to changes in urban runoff characteristics and water quality. The Department of Parks and Recreation projects that more people means more demand for water-based recreation, including on lakes that also serve as reservoirs for drinking water treatment plants. This raises concerns about the quality of those drinking water sources. See the urban land use management strategy in Volume 2 for more information on water-based recreation.

Post-World War II urban development in California reflects the state's automobile-dependent lifestyle. Patterns are characterized by fragmented and segregated land uses, low-density residential and strip commercial development, and a lack of connectivity within and between neighborhoods that use large quantities of land per capita. The result has been the consumption of prime farmland, open space, and habitat and an increased impact on other natural resources. Larger residential parcels tend to consume more water per capita than do smaller parcels. The creation of large amounts of impervious surfaces such as roads and parking lots results in the degradation of water quality by increasing the timing of surface runoff, altering streamflow and watershed hydrology, reducing groundwater recharge, and increasing stream sedimentation. It also increases the need for infrastructure to control storm runoff.

More population growth means more domestic wastewater discharges and urban runoff, which may in turn contaminate natural water bodies used as drinking water sources. Combined with demographic change, population growth can result in wastewater discharges that pollute California's waters with emerging contaminants such as endocrine disrupters as well as higher concentrations of traditional contaminants.

Future water demands can vary widely depending on how urban land use patterns develop in the future. Providing a growing population with a sufficient, affordable, safe, and reliable water supply is a major challenge facing water managers, especially in light of other challenges like water quality degradations that tend to diminish water supply.

Agriculture

California's agricultural production is large, efficient, and diverse, producing more than 350 commodities. Of the 75 crop and livestock commodities in which California leads the nation, 13 are produced solely within this state. In addition, according to the 1997 Census of Agriculture's ranking of market value of agricultural products sold, 8 of the nation's top 10 producing counties are in California. The state grows more than half of the nation's total fruit, nut, and vegetables, making California a net exporter of food to the rest of the United States and the world. The California Department of Food and Agriculture (CDFA) estimates that 14 percent of California's agricultural production is exported to other countries.

California has approximately 88,000 farming operations and about 27.6 million acres of farmland[1]. Agricultural land in California has been gradually shifting to urban or other nonagricultural uses. From 1990 to 2000 about 500,000 acres were converted from agricultural to urban or nonagricultural uses. Population growth and nonagricultural forces drive such development (Kuminoff, Sokolow and Sumner). It is uncertain at what rate this land conversion will continue in the future. If farm-to-urban conversion continues to increase at the same per capita rate, approximately 695,000 acres of California farmland would be converted to urban use per decade. By 2030, the total conversion would be 2.1 million acres or about 10 percent of the California farmland that existed in 2000 (AIC 2004).

Although agricultural acreage is expected to decline, yield growth in the quantity of agricultural crops per acre of land will continue to be the most important driving force in increasing the value of California food production over the next 30 years. Yield growth is expected to occur as a result of technological advances and climate change. In addition, the value of crops per acre-foot of water has increased in the past and is expected to continue to increase. Irrigation efficiencies have increased as more growers use drip and

[1] http://www.cdfa.ca.gov/exec/pa/pressreleases/PressRelease.asp?PRnum=04-008

sprinkler irrigation. Also, there has been a shift to commodities that produce more crop value per unit of water.

Since December 31, 2002, waste discharges for irrigated agriculture and timber harvesting must be monitored, placing much uncertainty over the future of runoff from these activities. Along with urban runoff, the U.S. Environmental Protection Agency has identified agricultural runoff as the most serious threat to water quality in the country. Municipal and industrial wastewater and even some urban runoff is already formally managed. However, agricultural runoff, application of biosolids to farms, and agricultural drainage, especially in the Great Central Valley, will remain significant and potentially expensive challenges, with no obvious consensus-based solutions.

Providing food and fiber crop products to Californians, as well as to other states and countries, consumes, and will continue to consume, more water than is consumed by all household uses. As population increases, the need for food and fiber crops also will increase. Over the last 20 years, water has been redistributed from the production of food and fiber to environmental and urban uses. In addition, available water supply for agriculture and other uses has been reduced because of continued groundwater overdraft in some areas.

The cumulative effects of overdraft and these reallocations diminish the reliability of irrigation water for food production. Agriculture cannot easily rebound in years of adequate water supply if its water supplies are greatly curtailed during dry years. Some agricultural areas do not have usable sources of affordable groundwater to tap during water shortages. Growers of permanent crops are particularly at risk. Even growers of annual crops may be unable to obtain long-term loans or short-term credit if they do not have access to a reliable water supply.

Agricultural water demand is primarily driven by the crop mix grown in the state. Agricultural operations are businesses that seek to produce food and fiber profitably. Crop markets, rather than water prices, generally dominate the grower's decision regarding which crop to grow. The grower considers the relative prices of agricultural commodities, the costs and regulations associated with labor, the costs of inputs needed to produce the crop, exchange rates, as much of California's agricultural production is exported, and the security of the water supply. Future water demands can vary widely depending on how agricultural land use patterns develop in the future.

AB 2587 requires the California Water Plan to include scenarios that are consistent with substantial continued agricultural production in California. A key phrase in the law is "neither the state nor the nation should be allowed to become dependent upon a net import of foreign food." In particular, the law specifies that DWR consider scenarios under which agricultural production in California is sufficient to assure that the state is a net food exporter and that the net shipments out of state are enough to cover its traditional share of "table food" use in United States (assumed in the law to be 25 percent) plus "growth in export markets." For water plan update 2008 DWR will re-examine the AB 2597 analysis based on food forecast prepared by the CDFA, as required by the bill. The CDFA food forecast was not available for this water plan update.

The University of California Agricultural Issues Center prepared *Future Food Production and Consumption in California Under Alternative Scenarios* (see Volume 4). The report concluded that California agriculture will produce substantial quantities of food crops. The value of California food production will more than keep up with rising population and income growth in California and the rest of the United States.

Environment

Ecosystem restoration is an investment in improving the condition of California's natural infrastructure. As we learn more about the link between water management and the health of the natural infrastructure, the benefits of restoration to water supply reliability and water quality improvements become more evident. As actions to restore ecosystems help increase the health and abundance of species protected under the State and federal Endangered Species Acts, there will be fewer ESA conflicts. As ecosystems like wetlands and sloughs are restored, their natural pollutant filtering capabilities will improve water quality. As floodplains and seasonal lakes and ponds are restored, groundwater recharge can increase. The result will be a more reliable, higher quality water supply supported by a sustainable ecosystem.

The major issues facing ecosystems statewide are aquatic and riparian habitat degradation and freshwater biodiversity declines that are directly linked to:

- physical alterations associated with on-stream dams, diversions, levees and bank armoring;
- deterioration of water quality including temperature, pollution, and low dissolved oxygen;
- the introduction of non-native invasive species; and
- long-term changes in the weather.

Over the past century, the scope of these threats has increased dramatically, paralleling population growth and demand for services provided by freshwater ecosystems (transportation, irrigation, recreation, land for development, municipal and industrial water supplies, and energy production).

In rural areas, the main pollution sources can come directly from land use practices both present and past. As an example, the Sierra Nevada Ecosystem Project notes the adverse impact that hydraulic mining, which ceased during the nineteenth century, is still having on numerous Central Valley rivers. In addition, logging and related road cuts are a major cause of high sediment loads to North Coast streams. Transportation corridors for vehicular access result in significant erosion into watersheds throughout the coastal and inland areas. Grazing impacts, such as increased erosion, loss of streamside vegetation, loss of groundwater recharge ability in mountain meadows, and nutrient inputs, have contributed to the overall water quality degradation.

Aquatic non-native species invasions harm public health, compete with native fisheries, and impede or block water deliveries. Because invasive species interfere with natural processes and do not necessarily provide the full range of benefits associated with native species, management is essential.

How these factors will continue to influence the environmental land use is unknown. A current challenge is to protect and improve the environment given the continued need for water for urban and agricultural use, problems with non-native species, water quality concerns, and climatic variability. Future environmental water demands can vary widely depending on how environmental land use patterns develop in the future.

Global Climate Change

Global climate change and other complex factors will likely change California's hydrology as recorded over the past century. While many uncertainties remain—primarily on the degree and timing of change—it is likely there will be reduction in the Sierra snowpack, an earlier snowmelt, and a rise in sea level. These changes have major implications for water supply, flood management, and ecosystem health.

Evidence continues to accumulate that global climate will have significant effects on water resources in California. Climate changes have occurred during the 20th century. Consensus in the scientific community is that measurable warming and other changes caused by human activities are already being observed. The prospects of significant changes warrant examination of how California's water infrastructure and natural systems can accommodate or adapt and whether more needs to be done to detect, evaluate, and respond to water resource system effects.

Managing water resources in this global climate change could prove different than managing for historical climate variability:

- Climate change could produce hydrologic conditions and extremes that are different from those the current systems were designed to manage.
- Climate change may produce similar kinds of variability but outside of the range for which current infrastructure was designed.
- Managing for climate change generally assumes that sufficient time and information will be available before the onset of large or irreversible climate impacts to permit managers to respond appropriately.
- Managing for climate change assumes that no special efforts or plans are required to protect against surprises or uncertainties.

For over a decade, scientists have been producing formal, peer-reviewed recommendations for integrating their work into policy. The Public Energy Research Program has established a regional climate change research center (Box 3-xx PIER Program). The Pacific Institute, in a literature search report for DWR, summarized the recommendations for coping and adaptation from several key peer-reviewed reports. This report and a DWR report on climate change impacts and recommendations for further research are included in Volume 4. An example on how California's water system might adapt to long-term climate warming was evaluated by the University of California, Davis using the CALVIN model (Box 3-xx CALVIN).

Box 3-xx Public Interest Energy Research Program

Box 3-xx CALVIN: An Analytical Tool to Evaluate Effects of Climate Change

One approach for planning for the uncertainties associated with global climate change is to perform sensitivity analyses with different assumptions on potential future conditions. Incorporating flexibility and robustness into our current system can help respond to the current uncertainties of climate change. Flexible systems work well under current climates as well as future climate conditions by allowing self adjustments or midcourse corrections without major economic and social disruptions. Adding robustness to systems can reduce vulnerability to climate change extremes similarly the way an insurance policy protects against a major loss.

Some of the expected impacts of global climate change are shown in the following sections.

Snowpack Changes

California's water managers rely on snowpack as a massive reservoir for natural water storage. Climate change that reduces snowpack reduces the total water storage in the system. The April–July runoff, an average of 14 million acre-feet in California major rivers, comes primarily from snowmelt. Computer modeling of California hydrology based on projected global climate change scenarios demonstrates consistent and significant effects on Sierra snowpack. Figure 3-xx (Model Simulation of Potential Change in Snowpack during this Century) shows a 52 percent reduction in the April–July runoff for a 2.1 degree C (3.8 F) of warming, well within the 1.4 to 5.8 degree C (2.5–10.4 F) range predicted by global climate models over this century. Changes in the timing of snowfall and snowmelt may make it more difficult to refill reservoir flood control space during late spring and early summer, potentially reducing the amount of surface water available during the dry season. Changes in reservoir levels also affect lake recreation, hydroelectric power production, and fisheries by altering water temperatures and quality. Snowpack changes may require changes in the operation of California's water systems and infrastructure.

Figure 3-xx Model Simulation of Potential Changes in Snowpack during this Century

Hydrologic Pattern

Historical records reveal changes in the pattern of April–July runoff, with an example plotted here for the Sacramento River (Figure 3-xx Historical April-July Runoff in the Sacramento River). In the last half of the century, the percentage of April–July runoff shows a progressive decline. This may indicate a decline in the percentage of water stored in the snowpack, leading to reduced spring and early summer river flows. The same effect is noted to a lesser degree on southern Sierra rivers. While these measurements are consistent with modeling simulations, more extensive monitoring of runoff and snowpack is necessary for greater understanding in changes of hydrologic patterns.

Figure 3-xx Historical April-July Runoff in the Sacramento River (Percent of Water Year Runoff)

Sea Level Rise

Global climate change is already leading to sea level rise. Figure 3-xx shows historical sea level rise at the Golden Gate. During the last century, sea levels increased by 0.2 meters (0.7 feet). During the next century, models project a median rise of 0.5 meters (1.6 feet) due to climate change (IPCC 2001). This could eventually disrupt ecosystems and communities in coastal areas. The biggest impact of sea level rise on California water supply could be in the Sacramento-San Joaquin Delta where sea level rise would increase pressure on the levees that protect low-lying lands, much of which already is below sea level. A single-foot rise in sea level would transform the current 100-year high tide peak in the western Delta into about a 10-year event. Thus, the rare high event could become a more frequent threat to the Delta levees and the role those levees play in protecting the sensitive Delta. Increased salinity intrusion from the ocean could degrade freshwater supplies pumped at the southern edge of the Delta. Available water supplies would be further reduced as more freshwater releases would be required from upstream reservoirs in order to repel ocean salinity.

Figure 3-xx Yearly and 19-Year Mean Sea Level at Golden Gate

Rainfall Intensity
Regional precipitation responses to climate change remain difficult to determine. If climate change results in larger individual precipitation events, this could affect current reservoir flood control operations and other flood management activities. Watershed protection activities would also be affected because greater storm intensities affect water quality due to changes in runoff.

Urban, Agricultural, and Environmental Water Demand
Plant evapotranspiration increases with temperature. Some laboratory tests indicate a reduction of water consumption due to increase in atmospheric carbon dioxide levels. Most researchers believe that higher water consumption with warmer temperatures may be partially offset by the carbon dioxide-based reductions. Thus, small but significant increases in crop and urban landscape water requirements are possible. More research is needed in this area.

Aquatic Life
Warmer air temperatures and changes in snowmelt will make it more difficult to maintain rivers cold enough for anadromous fish. Higher water temperatures increase the chemical and biological reaction rates, which affect the delicate balance of aquatic plants and animals.

Many extensive studies on climate change provide more detailed impacts on the environment. The Resources Agency's Joint Agency Climate Team (JACT) is developing initiatives on how each agency is addressing climate change. At present, the extent of climate change impacts is uncertain. As more sophisticated tools are developed, better quantification will be possible.

Vulnerability to Extreme Events

Major disruption to water infrastructure can occur from natural causes or intentional acts. The occurrence of a drought, flood, earthquake, wildfire, system malfunction, or unintentional toxic spill is beyond our control, even if the most strict safety measures are in place. Sooner or later, all of these extreme events will occur. The major uncertainty is when they will occur and how severe they will be. Will a drought that may occur within a decade be similar to a past drought or be longer and more severe? Will the next earthquake create even greater damage? Planning for extreme events can lessen their impacts when they do occur. In addition, regions can prepare risk assessments to aid decisions on how much protection they can afford to build into their system.

The effects of the following extreme events should be considered in preparing resource management plans.

Droughts
The most recent severe drought in California was from 1987 through 1992. In planning water supplies for future needs, the hydrology of the past century may not be a reasonable measure for future climate. The state's available flow record is rather short for determining hydrologic risks; it traces back only about 100 years with mostly qualitative information for another 100 years. Tree ring studies have shown extensive dry periods far exceeding the 6-year maximum recorded in the last century. (See Volume 4 Reference

Guide, for readings on the severity of extreme droughts in the Sacramento Valley and San Joaquin Valley and the Colorado River basin and on planning for extreme and prolonged drought conditions.)

Floods

Flood magnitude in a watershed depends on several factors such as the intensity and duration of precipitation, location of the storm center, area of precipitation, rain on snowpack, and antecedent soil moisture. The most severe storms for large drainage basins are slow-moving, with a long southwesterly fetch extending from Hawaii, commonly referred to as "pineapple express." The most severe storms for smaller basins in mountain areas are generally intense thunderstorms.

The two highest flood runoffs for the American River occurred in 1986 and 1997. Although these events were about 11 years apart, the statistical return-period for both these floods is 65 years. High flows seem to have been more predominant in the latter half than in the first half of last century. Because frequency is without a set pattern, prediction of the time and magnitude of a flood event would be impossible.

Damage due to flood may not be proportional to the runoff. Most catastrophic levee failures occur when a weak portion of the levee gives way, rather than from overtopping. Since 1950 all 58 California counties have been declared flood disaster areas no fewer than 3 times. In 1997, floods forced 120,000 Californians to evacuate homes, caused $2 billion in property damages, and killed 9 people. In comparison, floods in 1995 killed 28 people, a 1986 flood killed 13 people, and a 1955 flood killed 74 people. The 1986 flood proved more damaging to the Delta levees, and the 1997 flood caused more damage to the Sacramento River and San Joaquin River levee systems.

Levee failures are not rare occurrences in the Delta. During floods in combination with high tides and winds, levee failure can come from overtopping, seepage and erosion, sliding (rotational slip), and sloughing. Since original reclamation, each of the 70 islands or tracts in the Delta has flooded at least once. In some cases the cost of repairs exceeded the appraised value of the land. Figure 3-xx shows recent flooding in the Delta, 1967 to 1992.

Figure 3-xx Map of Flooded Islands in the Delta for Different High Flow Periods

Earthquakes

Aquatic structures including Delta levees are vulnerable to failure, especially during earthquakes. Because Delta levees and the California aqueduct span a large area, the vulnerability to an earthquake is higher than for an individual structure. Levee failures in the Delta could flood farmland and wildlife habitat, interrupt water supply deliveries to urban and agricultural users, and disrupt highway and rail use. Although there has never been a documented levee failure from a seismic event, the Delta has not experienced a significant seismic event since the levees have been at their current size.

The CALFED Levee System Integrity Program identified the risk of failure of Delta levees due to seismic events and developed recommendations to reduce levee vulnerability and improve levee seismic stability. The risk assessment also provides an estimate of the probability or likelihood that a damaging earthquake will occur (Figure 3-xx).

Figure 3-xx Map of San Francisco Bay Region Earthquake Probability

Several water districts already have plans to reduce earthquake impacts. Some measures include augmenting water supplies, improving delivery systems, and expanding groundwater recharge programs. For example, Calleguas municipal district lost its water supply when the single feeder line from the State Water Project was cut due to the Northridge Earthquake. Los Posas Project (250,000 acre-feet capacity, groundwater recharge program) now augments the water supply to this district.

Wildfire

Wildfire can result in short-term and long-term disruption to a water supply system and to other resources. Wildfire can damage project facilities, including burning wooden flumes and power transmission lines. The loss of vegetation on the watershed can change runoff patterns, reduce natural water storage, increase sedimentation, and create other long-term impacts.

Facility Malfunction

The State Water Project is over 30 years old, and the Central Valley Project is over 50 years old. These projects become more vulnerable to breakdowns over time as wear-and-tear increases the need to replace aging components. Much of the equipment and large fabricated components are unique, and spare parts would not be readily available if a sudden failure were to occur. It is generally impractical to store extremely large spare parts or parts on site. The replacement of many of these items from sources outside the United States is time-consuming, thereby increasing the vulnerability of the projects.

Water systems are often interconnected or have coordinated operations for optimal, multiple benefits. When an operation of one system depends on the smooth operation of another, the successful operation of the complete system can become vulnerable to a failure in either part (Box 3-xx). The June 3, 2004, failure of the Upper Jones Tract levee in the Delta was a reminder of the vulnerability of the Delta levee system and the interconnected nature of the levees with water supply operations. This facility malfunction occurred under normal operating conditions due to some unknown problem with the levee or its foundation. Data are still being compiled on the affects of the June 2004 levee failure. Delta levee failures during the summer period can be more critical than failures during the winter when river flows are higher. When river flows are low, the flooding of the island tends to pull salty water from the downstream estuary, impacting Delta and export water quality. Immediately following the 2004 levee break, DWR and the Bureau of Reclamation took the following actions to protect water quality:

- The Bureau of Reclamation increased releases of fresh water from Shasta Dam to help control salinity and opened the gates of the Delta Cross Channel to move Sacramento River water into the central Delta to repel sea water intrusion.
- The Department of Water Resources and Bureau of Reclamation reduced pumping at their south Delta export pumps to reduce the intrusion of sea water.
- The Department of Water Resources monitored Delta water quality at more than 20 sites and channel velocity changes in the Jones Tract area of the Delta.

Box 3-xx Potential Impacts from a Critical Levee Failure

Toxic Spills

Truck and railroad tanker accidents and other unintentional spills can release toxic chemicals into California's rivers and other conveyance facilities. For example, a 1991 railroad accident near Dunsmuir resulted in a toxic spill that destroyed all aquatic life within a 38-mile reach of the Sacramento River above Shasta Dam. A similar accident in another location could shut down a community's drinking water supply for an extended period of time.

Intentional Disruption

Vandalism is defined as malicious destruction of property. Acts of vandalism with respect to water infrastructure could be anything from defacing concrete structures and important notice boards, stealing copper fittings and aluminum handrails, shooting at a turnout structure gate, dumping pesticides or other chemicals into California waterways to dumping heavy material into the aqueduct. Most acts of vandalism occur in rural areas away from residential neighborhoods and frequent security patrols. For example, in the early 1980s, dredging of a one-mile stretch of the California aqueduct revealed concrete blocks, farm equipment, and stolen vehicles. A similar stretch in the Delta-Mendota Canal in the early 1990s revealed more than 80 abandoned vehicles.

Terrorist acts are generally designed to cause major damage and loss of life. With the increased tendency for people to build houses close to lakes, rivers, and waterways, the potential risk of terrorism increases. Increased security is needed to reduce the chances of terrorism causing outages in water service and other damage due to failure of portions of the water system.

Cyber threats pose a serious potential impact to the operational capability of water delivery and treatment systems. Many new water delivery and treatment systems are SCADA (Supervisory Control and Data Acquisition) controlled through the Internet. The operational costs of these modern systems are low because of remote access capability from a single command center to operate segments of or the entire system. However, the entire operation becomes vulnerable to hackers or cyber terrorists around the world who find the means to access the system. The State Water Project, unlike more modern water delivery systems, has a control system independent of the public worldwide web.

Most of the water supply infrastructure was constructed at a time when vandalism, illegal dumping, and the threat of terrorism were not common occurrences. Fencing around the facilities and structures was installed primarily for public safety reasons rather than to prevent vandalism or terrorism. Today, absence of active patrolling and lack of fencing along the waterways is attributed to the high rate of dumping in those areas.

Changing Policies, Regulations, Laws, and Social Attitudes

Changing policies, regulations, laws and social attitudes have dramatically altered California's water management over the past few decades. Some examples include the Central Valley Project Improvement Act (CVPIA), Colorado River Agreement, SWRCB Decision 1641 that requires more water to meet water quality standards, and listing of threatened and endangered species that require more water for environmental needs. It is impossible to anticipate how further changes in policies, regulations, laws, and social attitudes will affect future water management. However, incorporating operational flexibility into system design is one way to provide some insurance of continued successful system operation.

A sampling of the types of uncertainties that can lead to changing policies, regulations, laws, and social attitudes are in the following sections. Many other uncertainties are possible.

Relationships between Water Operations and Environmental Impacts

Environmental restoration science is a work in progress. Rarely do we have the necessary scientific information on a species, much less an ecosystem, to identify an exact course of action that will restore natural communities and processes. When precious resources and endangered species are involved, we often do not have the time or money to fully develop our scientific understanding before action is needed. Yet, the uncertainty can result in hesitation and delay. Improved understanding of ecological processes can lead to changes in policies, regulations, and laws.

Understanding watershed characteristics allows the use of adaptive management to operate projects and programs that best fit into the ecological settings. In some cases the description of these characteristics will highlight that important infrastructure, programs, or projects are not sensitive to watershed processes or have not been designed to capture the full ecological value of the projects. In these cases re-operation redesign may greatly improve the watershed compatibility of the projects. (See the Watershed Management Strategy in Volume 2).

Changing Plumbing Codes

Future changes in plumbing codes could allow use of innovative water fixtures to conserve water. Code changes could also allow dual plumbing for potable water and recycled water within residences that would provide opportunities for use of recycled water. These and other changes could alter water use and supplies.

Emerging Contaminants

The nature and impact of contaminants themselves may be changing in the future. Demographic change may create larger populations of persons, including the very old and the very young, vulnerable to risks from drinking water contaminants. Contaminants are emerging about which we know little. Detection levels for even existing contaminants are often lowered as understanding of their impacts improves, permitting the ability to find smaller and smaller concentrations of contaminants. Re-evaluation of health effects research often leads to re-regulation of known contaminants. Moreover, there is a growing demand from consumers, expressed in opinion surveys as well as in the marketplace, for high quality water.

Data and Analytical Tools

Our understanding and analyses of the uncertainties discussed above are complicated by limited data and insufficient analytical tools with which to completely evaluate how our water system works and how it might respond to changes. Analytical tools and data in California have not kept pace with the need to analyze the complex and interconnected water-related issues. Below are some areas where data and tools are currently inadequate for the analyses we need to conduct.

Data Gaps

There are a number of categories where data are simply not available or very resource intensive to compile. (See Volume 4 Reference Guide for a complete description of data gaps.) Some of the major data items required to complete regional flow diagrams and water balances (see Volume 3 Regional Reports) consist of more detailed and accessible land and water use information including information to separate applied water use versus consumptive water use. Significant data gaps include:

- Statewide land use data (for example, native vegetation, urban footprints, non-irrigated agriculture, and irrigated agriculture)

- Groundwater (total natural recharge, subsurface inflow and outflow, recharge and extractions, levels, and water quality)
- Surface water (natural and incidental runoff, local diversions, return flows, total streamflows, conveyance losses, and runoff to salt sinks)
- Depletions (evaporation and evapotranspiration from native vegetation, wetlands, urban runoff and non-irrigated agricultural production)

Data are currently available for some regions and not for others. For example, methodologies and data to estimate natural runoff are available for regions like Sacramento River and San Francisco Bay where the Delta is a control point. In areas like the South Coast Region, with no control point and substantial groundwater, the natural runoff is nearly impossible to estimate. In addition to natural obstacles, existing data are not easily aggregated or disaggregated to provide convenient access for all areas of interest. In addition, budget constraints limit extensive data collection and management necessary to quantify and track all the water in the state.

Analytical Tools

A critical issue facing California is the need for better tools to produce useful information about environmental objectives, water quality, economic issues, equity issues, groundwater and surface water interaction, and supply reliability. Also, there is a need to better integrate details associated with regional and local planning into the studies being conducted from a statewide perspective. For planning purposes, these tools must help planners predict a range of plausible future conditions and interactions on the statewide level and compare the performance of potential management actions. Many tools have been developed and applied in a comparative role, and their suitability for predictive studies vary widely.

Approach for Future Analysis

Several factors have caused DWR to rethink how it evaluates California's future water conditions. First, a great deal of uncertainty surrounds future climate conditions including the severity of future droughts and the effects of global climate change. Second, future water demands and competition over water supplies will increase with a population expanding at approximately 600,000 people a year and a desire to protect and enhance our environment. And finally, policy-makers and the public need more detailed information about the costs, benefits, and tradeoffs associated with implementing different water management strategies. In response, DWR has begun developing a new analytical approach for use in preparing California Water Plan Update 2008 that will evaluate and compare different management response packages, each for different future scenarios. The following sections describe the approach for future analysis in more detail. Box 3-xx (Evolving Analytical Approach) provides a brief comparison of analysis conducted for the water plan update 1998 (DWR 1998) and the approach outlined in this update. (Volume 4, Reference Guide, includes more discussion of future quantitative analysis for California water planning.)

Box 3-xx Evolving Analytical Approach

Example Future Scenarios for California

Rather than the traditional approach of planning based on assumptions for a single future forecast, the use of many different future scenarios tests how different management strategies may function under different future conditions. These plausible futures are not forecasts, but are differentiated by important assumptions about uncertainties (discussed above) in water and other resource conditions. Uncertainties can significantly affect which responses or actions may help respond to the uncertainties. Some actions in a plan may be common and implemented regardless of the scenario. Other actions may only be taken in response to specific conditions that develop in the future. This can take the form of a decision tree analysis that outlines different actions or responses that are implemented incrementally based on how the future unfolds.

Developing quantitative estimates of water demands and supplies for multiple future scenarios requires using available data and assumed relationships. DWR and stakeholders considered numerous factors that could vary in the future and developed three future scenarios that can be used to begin the analysis for water plan update 2008. Each scenario is a starting point for analyses. DWR and stakeholders may develop other scenarios, if needed, as work progresses:

- Scenario 1—**Current Trends**: Continue based on current trends with no big surprises.
- Scenario 2—**Resource Sustainability**: California is more efficient in 2030 water use than today while growing its economy and restoring its environment.
- Scenario 3—**Resource Intensive**: California is highly productive, respectful of the environment, yet less efficient in 2030 water use than today.

These are examples of three plausible scenarios to begin the analyses.

Table 3-XX shows the various factors that can vary between scenarios. Each of these factors must be quantified. The availability and resolution of data needed for the future scenarios varies widely. While the key factors have been identified, much work remains before an agreement is reached on the relationships between the factors and the methods to be used to quantify the factors shown in the table.

Table 3-xx Factors Affecting Regional and Statewide Water Demands and Supplies

As the work on Water Plan Update 2008 moves forward, DWR and stakeholders may find a need to add new factors to help answer questions about future scenarios or may decide to eliminate some factors. Although all the factors in the table are needed to define the strategies, DWR proposes to begin the analysis by varying only the factors in the upper portion of the table. These factors are primarily related to land and water use patterns. DWR may find a need to vary other factors in the table to gain insight to specific questions. (Volume 4 Reference Guide includes more discussion on these examples of future scenarios and responses.)

Following are brief descriptions for each scenario.

Scenario 1: Current Trends

- ***Population and Land Use:*** California Department of Finance projects the population of California to be 48.1 million people in 2030 with increasing population pressure in the valley and on the coast. Expanding metropolitan areas continue to dominate urban growth.
- ***Commercial and Industrial:*** Driven to reduce costs in the face of competition, industry has become more efficient in water use. Due to cost efficiencies, businesses have been reducing water use over time, primarily by replacing old or broken-down equipment with high efficiency machines.
- ***Agriculture:*** Farmers are increasingly using sprinklers and drip irrigation, moving away from flooding and furrows. Farmers produce more "crop per drop" through a variety of means, including changes in irrigation methods, although more improvement is possible. Increased cost of land is shrinking agricultural land availability. Irrigated crop acreage, which includes multi-cropping, is about 8.52 million acres, a reduction of about 9.7 percent from 2000, and multi-cropping acreage has increased by about 45 percent to 0.78 million acres from 2000.
- ***Environment:*** Environmental flows have reached levels needed to meet the objectives of CALFED's Ecosystem Restoration Program and the objectives in the Anadromous Fisheries Restoration Program. Water dedicated to wetlands has reached the "Level 4" supplemental water supplies for National Wildlife Refuges cited in CVPIA sections 3405 and 3406(b). Environmental effects of new projects continue to be mitigated to some degree but do not fully offset losses of habitat. Urban development continues to encroach on functioning floodplains in some areas.
- ***Naturally Occurring Conservation:*** The background conservation (changes in plumbing codes, etc.) is based on current agricultural and urban best management practices.
- ***Other Factors:*** Other factors remain unchanged (see Table 3-XX).

Scenario 2: Resource Sustainability

- ***Population and Land Use:*** Population in 2030 is 48.1 million. Citizens live in mixed use developments with native vegetation requiring little or no irrigation. An increase in population density means infill in existing urban areas and less new urban land being developed. This compact development has reduced the need for impervious surfaces benefiting open space, reduced runoff and other related issues. The cost of land is affecting the availability of housing.

- ***Commercial and Industrial:*** Industry has shifted from water-intensive processing to dry product assembly, reducing water use. Businesses have dramatically reduced water demand. They have received incentives accelerating the move to machines with high efficiency water use to accomplish standard tasks. Urban areas have a high degree of commercial and industrial productivity. California is a global leader in all types of recycling technology. Also, California has emerged as a leading industrial producer of environmental products and continues as a force in producing hardware for the technology industry.
- ***Agriculture:*** Crop acreage levels are at the year 2000 level or 9.44 millions acres. Any land acreage removed from agricultural must be replaced by a combination of new land coming into production or an increase in multi-cropping. Improved water management is increasing water efficiency. A healthy, efficient agricultural sector is able to produce more per acre and decrease applied water per irrigated crop acre.
- ***Environment:*** Projects are designed to achieve multiple benefits integrating ecosystem restoration with water supply reliability. Management actions are oriented toward the sustainability, restoration, and improvement of the natural infrastructure. Wetlands and native vegetation flourish through high environmental protection. Water dedicated to instream use and enhancing aquatic life is yielding increased populations. The sense of State government and its policies is to sustain a high degree of environmental protection.
- ***Naturally Occurring Conservation:*** Naturally occurring conservation is higher in the agricultural and urban sectors than under Scenario 1. Business and agriculture recognize the benefits of conservation and use efficiency measures that go far beyond the best management practices of the year 2000. Many houses are dual plumbed enabling residents to use recycled water for appropriate uses. Native vegetation and other innovative landscaping techniques have greatly reduced residential demand for landscape irrigation.
- ***Other Factors:*** Other factors remain unchanged from Scenario 1.

Scenario 3: Resource Intensive

- ***Population and Land Use:*** Population in 2030 is 48.1 million and is dispersed regionally. Expanding urban areas are commonplace. The Central Valley is experiencing air and water quality problems due to the stress of the large population. The population is more widely distributed, resulting in more outdoor residential water use (for example, larger residential lot size). Individuals tend to drive long distances to the workplace.
- ***Commercial and Industrial:*** California is a global leader in all types of recycling technology. Also, California has emerged as a leading industrial producer of environmental products and continues as a force in producing hardware for the technology industry. California's leadership in high tech hardware places constraints on its water resources because this industry is a high water-using industry that has not achieved advances in efficiency technology to limit its water use. Industry continues to rely on high water-using processes based on market conditions.
- ***Agriculture:*** Crop acreage levels out at the year 2000 level or about 9.44 millions acres. The healthy agricultural sector maintains past levels of food and fiber production. Low-density urban development expands onto prime farmland, but harvested acreage remains about the same due to increased multi-cropping and new lands coming into production. The annual volume of applied water per crop is high due to the changing nature of crops and the movement of agricultural production to lands with poorer soil quality.

- ***Environment:*** The level at which these factors can be plausible under this scenario will need to be determined; may not be the same level as Scenario 2.
- ***Naturally Occurring Conservation:*** Naturally occurring conservation in the agricultural and commercial and industrial sectors is lower than the current trends.
- ***Other Factors:*** Other factors remain unchanged from Scenarios 1 and 2.

The three scenarios are not intended to bracket potential future conditions, but offer a start for the analyses for water plan update 2008. An important element of scenario planning for the California Water Plan is that as the state grows, the water plan updates need to re-evaluate strategies based on revised plausible futures that incorporate increased certainty about future conditions or changes in water policies.

Changes in Water Demands for 2030 Scenarios

DWR will quantify water demands and supplies for each of the future scenarios as part of the work for water plan update 2008. For purposes of illustration of the general magnitude of changes in urban and agricultural water demands, DWR prepared preliminary estimates of water demands for year 2030 for each of these scenarios. (Volume 4, Reference Guide, includes documentation of the methods and assumptions used to produce these estimates.)

Table 3-xx shows preliminary demand ranges for these scenarios. The table includes estimates of the amount of water needed to stop groundwater overdraft and the general magnitude of water for meeting environmental flow objectives on major rivers and for other major uses. In some cases, some of this water can be recaptured to meet urban and agricultural demands.

Table 3-xx Estimated Changes in Water Demands for Example 2030 Scenarios

Other future scenarios will have higher or lower water demand estimates depending on the assumptions for environmental land use patterns.

Improving Analytical Tools and Data

DWR and the Water Plan Advisory Committee developed a new planning framework that identifies broad objectives for the water plan including disclosure of all technical assumptions (see Chapter 1 of this update). DWR and the advisory committee held several workshops with land use and resource planners, academics, policy analysts, and technical experts to build on and affirm advisory committee understanding about issues critical for the water plan to address. These conversations have been captured in mind maps that represent a web of relationships and ideas (See Volume 5 Technical Guide). These discussions identified the desire to address various crosscutting issues such as environmental objectives, land-use planning, and economics in different scenarios in this water plan. Quantifying these issues will require significantly more technical and quantitative information than was used in previous water plan updates.

Given the large quantity and complexity of data, relationships, and estimates desired, the water plan update team has organized technical information according to its potential interactions into a conceptual framework (See Volume 4 Reference Guide). This framework organizes information by (1) static information set by the user, which does not change for a given scenario, (2) dynamic information,

information that will be quantified using analytical tool(s) that explicitly consider the inter-relationships with other data, relationships, or estimates, and (3) the water management system, where most of the decisions are made within the analytical tools (often called decision variables). This conceptual framework is being used to evaluate progress in analytical tool and data development efforts.

DWR is participating in an effort by the California Water and Environmental Modeling Forum (CWEMF) to develop a long-term vision for analytical tools and data. This effort has derived a number of principles to guide the development and use of data and analytical tools (see Box 3-xx). The technical scope and magnitude of the desired analyses are unprecedented in California water planning. An intermediate report from the CWEMF is in Volume 4. Fully implementing this work will take several years and significant resources. It is recognized that qualitative approaches may be needed where there may not be sufficient data or adequate tools to quantify all costs or benefits. While several parts of the desired analyses have been conducted before, no previous quantitative study has ever been conducted so comprehensively and with such intensive stakeholder interaction.

Box 3-xx Principles for Development and Use of Analytical Tools and Data for California Water Problems and Solutions

Response Packages

Each future scenario will be used to test a number of different response packages, or sets of resource management strategies (see Volume 2). The development of different response packages may tend to favor or shape actions to help achieve a desirable future condition. Stakeholders can identify areas of agreement and where short-term resource management strategies can work well regardless of the future condition. In the long-term time frame, where uncertainties about future assumptions increase, there is generally sufficient time to revise the plan and use adequate response resource management strategies for the changed conditions.

Response packages should not be seen as what will be implemented without potential modification, but instead be used as a basis for identifying short-, medium-, and long-term actions of the plan. For illustrative purposes, Box 3-xx shows one sample response package. DWR and stakeholders will develop many other response packages as part of California Water Plan Update 2008.

Box 3-xx Sample Response Package

Evaluation Criteria

A significant difference in the new analytical approach is the addition of quantitative comparisons for different response packages of water resource management strategies. This performance evaluation of various mixes of water management strategies under plausible future scenarios will provide planners unprecedented access to relevant technical information and new insights. This quantitative insight can be used to help guide investments in regional and statewide water management actions. To help focus the quantitative analyses, DWR and stakeholders have developed a list of evaluation criteria that represents the technical information required to compare the response packages. These evaluation criteria are listed in Table 3-xx in addition to their associated management objectives and source of information.

Table 3-xx Evaluation Criteria for Achieving Water Management Objectives

Water Portfolios

The water portfolios provide comprehensive water balances and flow diagrams for 10 hydrologic regions, and the Mountain Counties overly area, covering the entire state (see Volume 3 Regional Reports). The flow diagram characterizes the hydrologic cycle and documents sources of water such as precipitation and inflows into California, and tracks the water as it flows (through many different uses) to its ultimate destination. Since data for some categories are not measured for many regions of the state, the current water portfolios have data gaps. Identifying additional data collection and management activities in update 2004 is an important step in improving the water portfolios for future water plan updates.

The water portfolios provide a convenient display of the water balance within each region. Volume 3 includes water portfolios for three recent years (1998, 2000, and 2001). There is a need to continue developing actual year water portfolios as data becomes available each year. Once portfolios for enough actual years are developed, they can be sequenced and/or averaged into different wet, dry, and average conditions to help planners identify current conditions as well as base conditions for forecast years. Without contiguous actual years, trend-based data would be needed. The water portfolios also provide a convenient way to display results of the analyses of future scenarios and response packages.

Expected Information from Analyses

The above approach for analyses will provide useful water-related information that will be included in California Water Plan Update 2008. These analyses will not take the place of more detailed regional planning efforts, but will provide insights on statewide conditions to aid the regional planning efforts. DWR, with stakeholder input, is continuing to define the details of the analytical approach. Assuming that the DWR obtains funding and staff resources to support the analytical approach, the expected information for incorporation in update 2008 will include:

- Water and sewer rate data for the utilities and time frames for data contained in DWR's Public Water Supply Survey database
- Correlated local/regional demographic information with per unit water use rates by area
- Correlated climate conditions with per unit use rates over time
- Accessible on-line data for water portfolios and water balances for each region
- Accessible on-line data on types and locations of urban, agricultural, and environmental water use (for example, amount of cotton grown in a county and how much water it uses)
- Screening tools that allow evaluation of factors and display of impacts that are important to each region and to the state as a whole
- Screening level of analysis to show which response packages generally have merit in various regions and which do not
- Tradeoffs of different response packages for each future scenario and for each region
- Interactions (synergies and constraints) between regions for each response package
- Highlighted resource management strategies that appear viable in each region for multiple future scenarios
- Highlighted resource management strategies that could be implemented incrementally if certain future conditions arise
- Priorities for public investment for regional resource management strategies

Boxes

Figures

Tables

Box 3-xx Public Interest Energy Research Program

In conjunction with affected state agencies, the Public Interest Energy Research (PIER) Program administered by the California Energy Commission has developed and is implementing a climate change research plan for California. The PIER Program has established a regional climate change research center with the goals of:

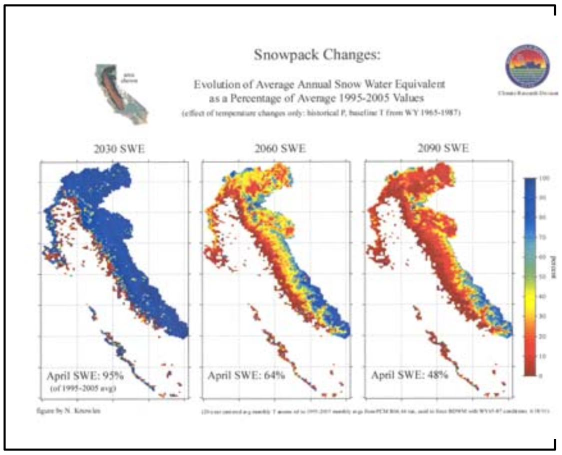
- Improving the understanding of the possible physical and economic impacts of climate change
- Developing robust adaptation and mitigation strategies for California.

In support of future updates of the California Water Plan, the California Climate Change Research Center (Research Center) is funding (1) the development and maintenance of a comprehensive climatic data base for the state and the analysis of meteorological and hydrological trends; (2) the monitoring of meteorological and hydrological parameters in some key remote locations using innovative remote sensing devices; (3) the development of climate projections for the state using regional climate models at levels of resolution appropriate for water resources impact analyses; and (4) the study of water resources impacts under different climatic projections. The Department of Water Resources is a key co-sponsor of these research activities.

Box 3-xx CALVIN: An Analytical Tool to Evaluate Effects of Climate Change

From 1998–2003 the University of California, Davis (with funding from the Resource Agency, CALFED, and California Energy Commission) developed a preliminary analytical tool, named CALVIN, to quantify the potential of integrated long-term solutions for California water management. The tool integrates existing surface water, groundwater, and water demand data in an integrated economic-engineering framework for California's inter-tied water system (covering 92 percent of California's population and 88 percent of its irrigated area). In developing the computer model, significant weaknesses and gaps in water data were identified and documented. The model and its results have been peer reviewed and show preliminary insights into economically promising possibilities for California water management. More importantly, the tool demonstrated concepts in advanced data management, documentation, and analysis that may be useful for future statewide and regional water policy and planning analysis. The CALVIN model has been applied preliminarily to examine statewide potential for regional and statewide water markets and how California's water system might adapt to long-term climate warming.

Figure 3-xx Model Simulation of Potential Changes in Snowpack during this Century



Source: (Knowles and Cayon 2001)

Figure 3-xx Historical April-July Runoff in the Sacramento River (Percent of Water Year runoff)

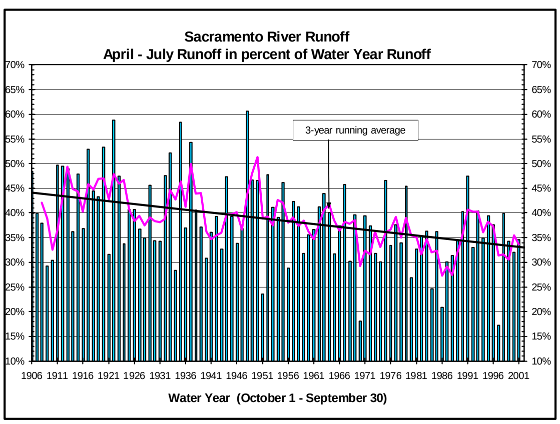


Figure 3-xx Yearly and 19–year Mean Sea Level at Golden Gate

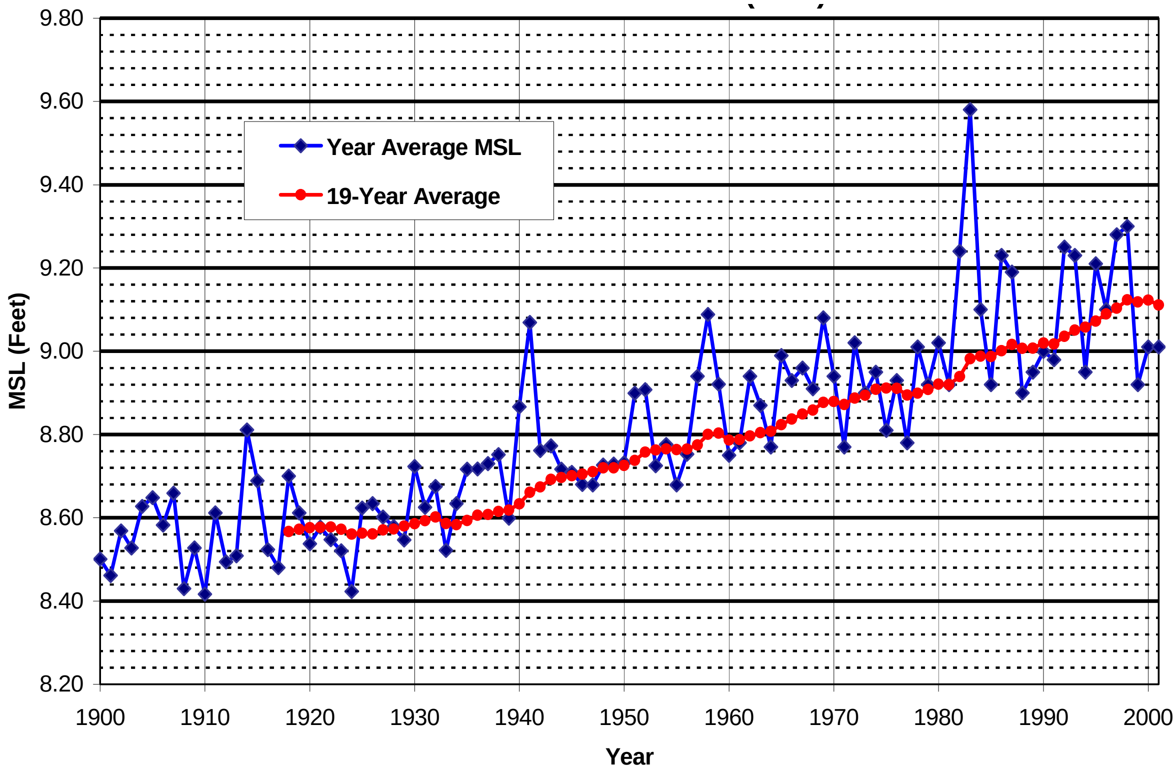
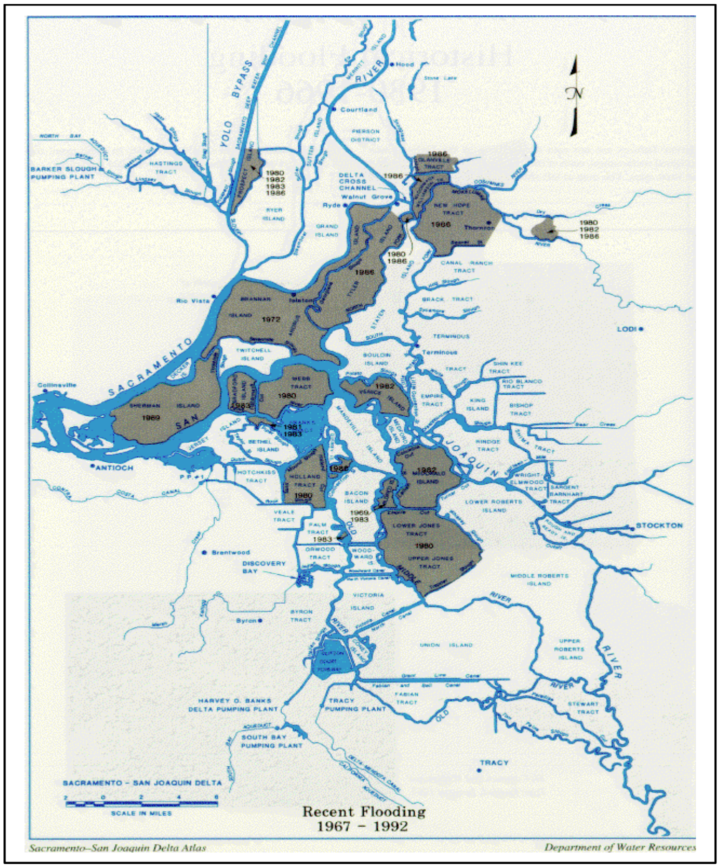
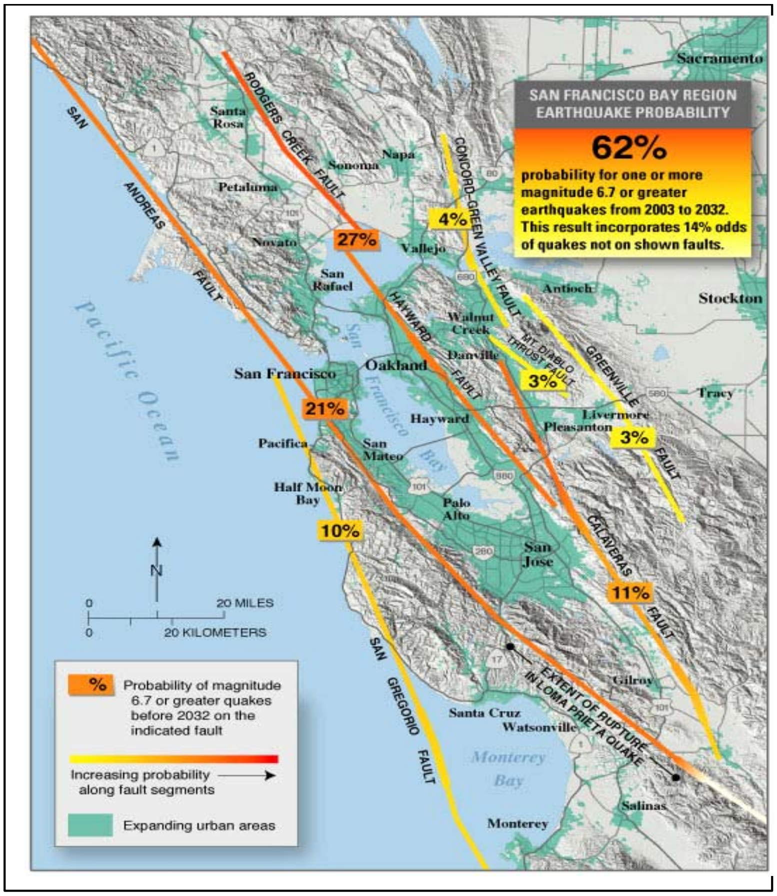


Figure 3-xx Map of Flooded Islands in the Delta for Different High Flow Periods



Source: DWR 1993 *Sacramento San Joaquin Delta Atlas*

Figure 3-xx Map of San Francisco Bay Region Earthquake Probability



Probability of a 6.7 magnitude earthquake within 30 years in Bay Area
(2003 earthquake probability study - USGS)

Box 3-xx Potential Impacts from a Critical Levee Failure

- Significant increase in salt water in the Delta during dry periods and associated degradation of export water quality. A Delta levee failure during the summer of 1972 required release of about 467,500 acre-feet of stored water to flush and dilute salt in the Delta.
  (Testimony by W. R. Gianelli to Senate Committee on Ag and Water Resources)
- Shut-down of the State and federal water system for the duration of poor-quality water in the Delta.
- Loss of homes, farm income, jobs, loss of critical habitat.
- Long-term degradation of export water quality due to salt mixing if the island is not reclaimed.

Box 3-xx Evolving Analytical Approach

Since the California Department of Water Resources (DWR) published the California Water Plan in 1957, analyses for subsequent water plan updates have continued to evolve to meet changing needs for information. Early in the series of updates, the reports included only average year water budgets (water demand, supplies, and shortages). Not until updates in 1993 and 1998 were estimates for drought budgets included. The most recent prior update, Bulletin 160-98, provided readers with estimates of the magnitude of dry-period water shortages in different areas of the state and also presented some options for reducing those shortages.

DWR and stakeholders want a more comprehensive analysis that includes economics, water quality, and environmental and social considerations rather than focusing on water budgets presented Bulletin 160-98. Considering the large amount of work required to include these changes, the analytical work could not be completed for use this water plan pdate. Without this analysis, update 2004 lacks the information to make the types of regional-specific water budget comparisons afforded by Bulletin 160-98. However, update 2004 provides qualitative discussions and presents the analytical approach for use in update 2008 and beyond. If the past is any indication, we expect the analytical approach to continue to evolve long after 2008 is completed. Some changes in the analytical approach proposed by Water Plan Update 2004 include:

Approach

- Bulletin 160-98 used and expanded the analytical methods that was developed in Bulletin 160-93.
- Update 2004 presents a new analytical approach for multiple future conditions (scenarios) and multiple alternative response packages in update 2008.

Current Conditions

- Bulletin 160-98 used trend analysis to normalize year 1995 to represent typical average year.
- Update 2004 presents water portfolio (see Volume 3) information for three actual years (1998, 2000, and 2001). These three years do not allow drought or other planning analysis that will be possible after water portfolios for several additional actual years are developed.

Future Conditions

- Bulletin 160-98 projected a single future condition to year 2020 for land use, water demands, and supplies.
- Update 2004 presents an approach to consider multiple plausible, yet very different, future scenarios to year 2030 for analysis in update 2008. Update 2004 presents the concept of multiple different response packages for each future scenario for analysis in update 2008.

Water Shortages

- Bulletin 160-98 computes the difference between water demands and supplies as the shortage.
- Update 2004 presents an approach to balance water demands and supplies for each response package by including economics, water quality, and environmental and social considerations.

Potential Future Actions

- Bulletin 160-98 presented options that could be used to reduce shortages by area of the state.
- Update 2004 presents an approach to allow comparison of many different response packages at the regional level.

Response packages are sets of the Resource Management Strategies (see Volume 2). All of these changes need to be supported by development of improved data and analytical tools. Data and modeling results will be presented in the water portfolio format (see Volume 3).

Table 3-xx Factors Affecting Regional and Statewide Water Demands and Supplies

FACTOR [1]	SCENARIO 1 CURRENT TRENDS	SCENARIO 2 RESOURCE SUSTAINABILITY	SCENARIO 3 RESOURCE INTENSIVE
Total Population	DOF	DOF	Higher than DOF
Population Density	DOF	Higher than DOF	Lower than DOF
Population Distribution	DOF	DOF	Higher Inland & Southern; Lower Coastal & Northern
Commercial Activity	Current Trend	Increase in Trend	Increase in Trend (Same as Scenario 2)
Commercial Activity Mix	Current Trend	Decrease in High Water Using Activities	Increase in High Water Using Activities
Total Industrial Activity	Current Trend	Increase in Trend	Increase in Trend (Same as Scenario 2)
Industrial Activity Mix	Current Trend	Decrease in High Water Using Activities	Increase in High Water Using Industries
Total Crop Area (Includes Multiple Cropping)	Current Trend	Level Out at Current Crop Area	Level Out at Current Crop Area
Crop Unit Water Use	Current Trend	Decrease in Crop Unit Water Use	Increase in Crop Unit Water Use
Environmental Water-Flow Based	Current Trend	High Environmental Protection	High Environmental Protection
Environmental Water-Land Based	Current Trend	High Environmental Protection	High Environmental Protection
Naturally Occurring Conservation [2]	NOC Trend in MOUs	Higher than NOC Trend in MOUs	Lower Than NOC Trend in MOUs
Urban Water Use Efficiency	All Cost Effective BMP's in Existing MOU's Implemented by Current Signatories (present commitments)		
Ag Water Use Efficiency	All Cost Effective EWMP's in Existing MOU's Implemented by Current Signatories (present commitments)		
Per Capita Income	Current Trends		
Seasonal/Permanent Crop Mix	Current Trends		
Irrigated Land Retirement	Currently Planned		
Hydrology	Essentially a Repeat of History		
Climate Change	Essentially a Repeat of History		
Colorado River Supply	Equal to 4.4 Plan		
Existing Inter-Regional Import Projects	Current Conditions		
Flood Management	Current capacities, management practices and operations		
Energy Costs	As Projected From Current Trends		
Ambient Water Quality	Current Conditions		
Drinking Water Standards	Current and Planned		
Ag Discharge Requirements	Current and Planned		
Urban Runoff Mgmt.	Current Level of Use		
Recreation	Present Demand Trends Continued		
Desalting	Current Level + Permitted/Financed		
Recycled Water	Current Level + Permitted/Financed		
Water Transfers Within Regions	Currently Approved Transfers		
Water Transfers Between Regions	Currently Approved Transfers		
Integrated Ground & Surface Water Mgmt.	Current Level + Permitted/Financed		
Groundwater Storage	Current Level + Permitted/Financed		
Surface Water Storage	Current Level + Permitted/Financed		
Conveyance Facilities	Current Level + Permitted/Financed		
Rate Structure	Current Practices		
Cost Recovery	Current Practices		

(1) Factors should be considered as an initial list that will be modified, as needed, as analyses proceed for Water Plan Update 2008.

(2) Naturally Occurring Conservation is the amount of background conservation (changes in plumbing codes, etc.) occurring independently from the BMP and EWMP programs.

Table 3-xx Estimated Changes in Water Demands for Example 2030 Scenarios

Water Demands[a]	Scenario 1 Current trends	Scenario 2 Resource sustainability	Scenario 3 Resource intensive
Urban	_ MAF - _ MAF	_ MAF - _ MAF	_ MAF - _ MAF
Agricultural	_ MAF - _ MAF	_ MAF - _ MAF	_ MAF - _ MAF
Environmental objectives	_ MAF - _ MAF	_ MAF - _ MAF	_ MAF - _ MAF
Stop groundwater overdraft	1 MAF – 2 MAF	1 MAF – 2 MAF	1 MAF – 2 MAF
Total	_ MAF - _ MAF	_ MAF - _ MAF	_ MAF - _ MAF

a. These estimates are only to illustrate the general water demand range for each scenario. These three example scenarios are not intended only provide a general indication of how the demands for scenarios may vary, not to bracket the range of potential future water demands. DWR will refine these numbers for Update 2008.

MAF = million acre-feet

Box 3-xx Principles for Development and Use of Analytical Tools and Data for California Water Problems and Solutions

Strategy

1. Analytical tools and data should be based on expected long-term water problems and the decision-making processes they are expected to inform.
2. An official strategic analytical approach should identify the technical objectives, roles, and responsibilities of major data collection efforts and analytical tools.
3. Strategic documents should undergo periodic internal and external review, in discussion with major stakeholders, to identify needs for additional analytical tool and data development.
4. A frequently updated implementation document should outline short-term and long-term efforts, budgets, and responsibilities for continuous improvement of analytical tools and data with policy for continued user, local agency, and stakeholder involvement.

Transparency

5. All data and models should have significant documentation.
6. Known limitations and appropriate applications should be documented.
7. Model applications should include explanatory and self-critical discussions of results.
8. All data, models, and major reports should be in the public domain and available on the web.
9. A common glossary of key terms should be maintained.

Technical Sustainability

10. Modularity: Major analytical tools should be designed and implemented to fit modularly in the larger strategic analysis framework, allowing models to be tested, refined, updated, and replaced without major adjustments to other components.
11. Adaptive information management framework: Major data and information efforts should fall within a larger information management framework, including protocols for data documentation and updating, and documentation of limitations.

Coverage

12. The spatial coverage of the basic data and analytical framework should be statewide and encompass a wide variety of water management options and processes.
13. Local and regional water management and resources should be explicitly represented to allow consistency among local, regional, and statewide studies.

Accountability and Quality Control

14. Explicit model testing should be undertaken, documented, and made available for major analytical tools.
15. Protocols and guidelines for model use should be developed and adhered to.
16. Major analytical products should undergo review by external unaffiliated experts and local agencies whose systems are included in the model(s).
17. In developing and maintaining analytical tools, significant efforts should be made to involve local agencies and stakeholders, including users groups or other cooperation mechanisms for widely used analytical tools.

Box 3-xx Sample Response Package

This sample response package represents those strategies that most agencies are currently implementing. These strategies, packaged together, are being implemented by State, regional, and local organizations. They are technically and institutionally feasible. They make sense for the environment. They are economical and do not raise significant equity issues.

Test Purpose: Recognizing that agencies can continue to implement those strategies that are supported by stakeholders, testing this response will determine how effective this package will be in meeting future water needs. The needs will be determined in Phase 2 for each of the alternative futures.

Goal: The goal of this package is to emphasize maximum implementation of current strategies supported by stakeholders.

Strategies: This response package will include options from strategies identified in this category that are widely supported by stakeholder groups. It consists of options that are proven effective and are currently in use. The costs and benefits are generally known and can be quantified or acceptable qualitatively to justify implementation. This response package would also include options from strategies that stakeholders widely support but somewhat conditional based on the uncertainties of costs and benefits to justify implementation. An example would be the amount of urban water conservation that could be achieved using acceptable new technologies.

Table 3-xx Evaluation Criteria for Achieving Water Management Objectives

Water management objective	Evaluation criteria	Information source
Water supply benefits (to any use sector)	New supplies Transfers and other reallocations	Water portfolio; water management/system modeling
Improve drought preparedness	Ag service reliability Urban service reliability Environmental service reliability	Water management/system modeling
Improve water quality	Agriculture Environmental Groundwater Recreation Urban Contaminant concentrations	Data monitoring/compilation and system modeling
Improve operational flexibility and efficiency	Conveyance capacity improvements Storage capacity improvements Diversity of management options Regulatory effects	Water management/system modeling
Reduce flood impacts	Flood risk	Economic analysis and system modeling
Environmental benefits	Fisheries Native habitat/vegetation Wildlife	Data monitoring/compilation, biological opinion, and system modeling
Energy benefits	Consumption Production	Data monitoring/compilation and system modeling
Recreational opportunities	Sport-fish populations Reservoir-based (boating, swimming, camping, etc.) Watercourse-based	Data monitoring/compilation and system modeling
Reduce groundwater overdraft	Pumping requirements Storage capacity Salinity intrusion Groundwater levels	Data monitoring/compilation and system modeling
Other indicators	Catastrophic vulnerability	Economic analysis and system modeling
	Economic/financial	Economic analysis and system modeling
	Public Trust and environmental justice	Participation in planning; assistance to low-income and disadvantaged communities